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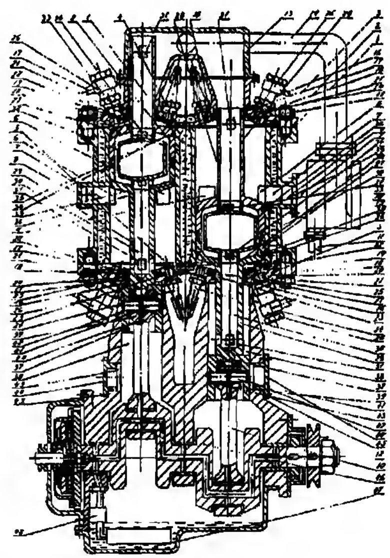
(54) Title: AN INTERNAL-COMBUSTION ENGINE

(57) Abstract

The invention "An Internal-Combustion engine" refers to a turbo-compressor with a direct fuel-injection in the cylinders (2) which are double-sided covered by cylinder heads (4, 5). Referring to the petrol variant of the engine, the injection of the fuel is accomplished by low-pressure injection system using injection nozzles (26) which are mounted in the cylinders' walls, and the combustion of the air-fuel mixture is done traditionally by ignition plugs (24), mounted in the cylinder heads. Referring to the diesel variant of the engine the injection of the high-pressure fuel from the fuel-injection pump is accomplished using the traditional way of fuel-injection nozzle in the heads of the cylinders (2). The gas distribution in the one-stroke turbo-compressor engine is realized by the heads of hollow double-stroke pistons (27) on which are mounted central hollow piston rods (29) on the bottom piston heads and tube-like air-conductors on the top piston heads (4). Both have orifices (38) in their walls which are situated at such a distance from the piston heads which is equal to the piston travel. The air, fed from the turbo-compressor (10) by a delivery line, flows within the pressurized space covered by a joint for all top heads hood blows down through the orifices in the walls of the air-conductors into the top half-part of the cylinders when the pistons reach bottom dead centre. The air passes through and cools from inside the double-stroke hollow pistons (27) and then through the orifices of the piston rods the air flows and scavenges the bottom half-parts of the cylinders when the pistons reach top dead centre. In the pistons are installed hollow thin-walled bodies in order to improve the cooling of the piston walls and heads. The piston rods (26) are connected on the opposite end to crossheads (37) which are connected to pitmans hubs of the crankshaft mechanism. The crossheads (37) move like pistons (27) in cylinders in the engines body which are coaxial with the engine cylinders (2).



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# AN INTERNAL-COMBUSTION ENGINE

## TECHNICAL SPHERE

The invention refers to an internal-combustion engine and particularly to a turbo-compressor engine with a direct fuel injection in its cylinders.

## PRECEDING TECHNICAL STATE

World-wide known are the petrol and diesel piston machines which are operating as two-stroke internal-combustion engines. Their cylinders - one, two (or more in an engine block) are constructed statically, coaxial, opposite in a row or at an angle to the engine block, and their external end is hermetically covered with a separate or joint cylinder head. In every petrol engine's head are mounted one or two ignition plugs and a fuel injection nozzle in the diesel engine's head. Every cylinder has exhaust and cylinder scavenging orifices on its inner wall. The petrol engine has a third orifice which connects the crankcase through a carburettor to the atmosphere. Inside the cylinders are installed mobile pistons with seal piston-rings. A piston pin connects the piston to a pitman and the latter - to a crankshaft which rotates on crankshaft bearings in the engine's body.

By their motion in the cylinders the pistons are realising the gas-distribution processes in the engine, e.g. starting from bottom dead centre to bottom dead centre the pistons at the same time perform the 'exhaust of burnt gases', 'cylinder scavenging' and 'compression' strokes (after closing the exhausting orifices in the cylinders up to top dead centre). Regarding the petrol engine, a little bit before the piston reaches the top dead centre, its bottom edge connects the crankcase through the carburettor to the atmosphere and within the crankcase is created a vacuum space that prompts an air-fuel mixture formation in it. A little bit before the pistons reach their top dead centre, an ignition spark is generated in the combustion chambers by the ignition spark plug, that inflames the compressed air-fuel mixture. Regarding the diesel engine, a portion of fuel is fed by the fuel injection nozzle (in high pressure environment in the chamber) which is also inflamed.

An 'expansion' stroke is started in the cylinder and the high pressure gases eject the piston from top to bottom dead centre. After about $^2/_3$ of the piston travel, its head edge opens the exhaust orifices in the cylinder and the gases of about 3 bar pressure leave the cylinder, which is actually

the 'exhaust of burnt gases' stroke. A little bit before the beginning the 'exhaust of burnt gases' stroke the piston head edge opens the cylinder scavenging orifices which are connected to the crankcase (via channels) and in the cylinder starts the cylinder 'air scavenging' stroke - regarding the diesel engine, or the 'fresh air-fuel mixture scavenging' stroke - regarding the petrol engine. The piston compresses the air or the air-fuel mixture in the crankcase by its travel from top to bottom dead centre, after the piston's bottom edge covers the orifice connecting the carburettor to the crankcase. The 'air or fresh air-fuel scavenging' strokes from the crankcase and the 'exhaust of burnt gases' strokes are running at the same time till the moment when the piston in its travel from bottom to top dead centre covers the scavenging orifices in the cylinder's wall. Consequently, it covers the exhaust orifices too. The 'burnt gases exhaust' stroke is finished and the 'air or air-mixture compression' stroke is started. It lasts till top dead centre.

Regarding the two-stroke engines, the efficiency coefficient is low because of the impossible complete burnt gases scavenging out of its cylinders and also the impossible complete air or fresh air-fuel mixture filling, due to the fact that the gas-flows of the burnt gases and the air (or the fresh air-fuel mixture) are co-directed and they partly mix. Furthermore, the space above the exhaust orifices turns out to be a dead zone which is not well scavenged, neither filled completely.

Regarding the construction of all piston two- and four-stroke internal-combustion engines using crankshaft mechanism, the gas and inertial forces in all stages of the gas-distribution process evoke a pistons, wrist pin, connecting rod and crankshaft load which generates forces that press the pistons to the cylinders' walls which leads to elliptical wearing. After a few hundred operating hours, due to the expansion of the clearance between the pistons and cylinders walls (as a result of their wearing) the preliminary compression rate and the gas pressure (during the expansion stroke) both begin to decrease. The efficiency coefficient and the engine's power decrease proportionally to the mentioned wearing. The emission characteristics aggregate too - the engine burns oil in its cylinders.

The target of the invention is to create an internal-combustion engine with a turbo-compressor, direct fuel injection in its cylinders, with a larger litre power, higher efficiency coefficient and non-elliptical wearing pistons, cylinders and piston-rings.

# TECHNICAL ESSENCE

In reference with the invention the task is achieved as follows: in the centre of every cylinder installed in a cylinder block, there is at least one exhaust orifice which is connected through an exhaust channel in its wall to joint for all cylinders manifold pipe. The manifold pipe is connected to an turbo-compressor's inlet. Every cylinder is hermetically double-side covered by top and bottom cylinder heads having central orifices, coaxial to the cylinders. Inside the cylinders are installed hollow double-stroke pistons which top heads are connected to central coaxial tube-like air-conductors, and on the bottom heads are mounted hollow piston rods. The coaxial hollow air-conductors and the piston rods, having scavenging holes in their walls (located at a distance from the piston heads which is equal to the piston travel), are fitted in the central orifices of the top and bottom cylinder heads. In the double-stroke piston cavity (the pistons are assembled of two parts) are fitted statically thin-wall bodies for providing an intense cooling of the piston heads and walls by the air passing through them. The top cylinder heads are hermetically covered with a hood and its inner space is connected to the turbo-compressor's delivery line. Regarding the diesel engine, in the top and bottom cylinder heads are fitted heating plugs and fuel-injection nozzles for a high pressure fuel feed to the compressed cylinder chambers. Regarding the petrol engine, in the top and bottom cylinder heads are fitted spark plugs which inflame the compressed air-fuel mixture. The latter could be formed by the traditional way using carburettor which is mounted at the suction (or delivery) line of the turbo-compressor or by a direct low-pressure fuel-injection in the air within the cylinders which is done by using fuel injection nozzles mounted on the cylinders.

The double-stroke pistons, the air-conductors and the piston rods are sealed from the cylinders and central orifices by at least two rings suited in one groove.

The hollow thin-wall bodies which are situated inside the double-stroke piston cavity are fixed to the pistons' heads by thin-wall tails that are provided with orifices which link the pistons' cavities with the inner holes of the air-conductors and the piston rods.

The piston rods are connected by a crosshead to a crankshaft mechanism mounted in the engine body. The engine body is fixed to the bottom cylinder head of the cylinder block.

The cylinders, pistons, piston rods and air-conductors are not coercively oiled by the engine's oil system. In case the double-stroke pistons, piston rods and air-conductors are manufactured from lubricating metalo-graphitic material then as an additional lubricating substance will

be used the injected fuel and soot which are the result of the combustion within the cylinders. In case the seal rings are manufactured from metal then an addition of a very low oil content in the injected fuel is necessary.

As it was above mentioned, the heads and the walls of the double-stroke pistons are very intensively heated. Their cooling is coercively realized by introducing fresh air necessary for the combustion process, passing through the pistons and blowing down the top and bottom cylinder half-sections.

The burnt gases discharged from the exhaust manifold pipe rotate the impeller and the compressive turbines of the turbo-compressor.

The invention provides the following advantages:

The two-cylinder engine variant is realized as one stroke turbo-engine having high (or low) pressure direct fuel injection in its cylinders; considering its power performance it can be compared to a similar diesel or petrol eight-cylinder four-stroke engine or four-cylinder two-stroke engine having the same piston diameter, travel and revolutions.

The total mass, the mass of the engine's mobile parts and their inertial forces are considerably reduced.

The invention avoids the gas-distributing mechanism with its coercive driving, oiling, inertial forces, sealing, friction, wearing and ignition timing which all mentioned simplifies the construction.

The compulsory co-direction gas-exchange under pressure provides the complete scavenging and cylinders' air-filling which ameliorates the engine's combustion process and increases its litre power.

The axial inertial forces of the rectilinear traveling pistons, piston rods and air-conductors are completely balanced by the counteraction of the gas forces of the air compression in the opposite half of the cylinder which in this respect is a performance of an effective work.

The cylinders, pistons, piston rods and air-conductors do not wear elliptically due to the lack of forces pressing them during their motion to each other and that's why the power characteristic of the engine won't be changed after a long-run exploitation.

The engine will have better environmental performance due to the fact that the fuel will completely burn in the exhaust manifold pipe in lack-of-air conditions.

## ELUCIDATION OF THE APPLIED FIGURES AND EXAMPLES OF THE INVENTION'S REALIZATIONS

An exemplary realization of the invention is illustrated on the applied fig. 1 which is a full longitudinal section along the axle of a two-cylinder one-stroke turbo-compressor internal-combustion engine with a direct fuel-injection in its cylinders.

Fig. 2 shows the petrol variant of the engine which has low-pressure fuel injection in its cylinders.

In reference with the invention its target is achieved as follows: the parallel walls of the cylinder block 1 having two immobile fitted coaxial cylinders 2 in it, are frontally fixed by a binder screw connection and hermetic gaskets 3, to the top 4 and bottom 5 cylinder heads. The cylinders 2 which could be water or air cooled, with or without cylinder sleeves are in this case shown with water cooling and without cylinder sleeves.

The cylinders 2 have in the centres of their ambient walls one, two or more exhaust orifices 6 which are mutual and connect the top and bottom inner spaces of the cylinders 2; they lead through exhaust channels 7 which are shaped in their walls to a joint manifold pipe 8 leading to the inlet of the impeller 9 of the turbo-compressor 10. The outlet of the impeller 9 is connected through an exhaust pipe system 11 to the atmosphere.

The bottom head 5 of the cylinder block is realized as a part of the engine's body 12. The top head 4 is covered hermetically by a hood 13 which through a tube manifold pipe is connected to the outlet of the delivery turbine 15 of the turbo-compressor 10 which is coaxially mounted to the impeller 9.

The top 4 and bottom 5 heads have coaxial to the cylinders orifices 16 connected to the cylinders' inner space. The central orifices 16 in heads 4 and 5 (by the cylinders 2 side) have two coaxial cylindrical seats with smaller 17 and larger 18 diameter. The seats with larger diameter 18 have circlip grooves 19 in their ambient wall. In the inner seats 17 are fitted two (or more) cut metal or mtalo-graphitic inside sealing rings 20 that by the frontal wall of the inner seat 17 are limited, in order to prevent one-direction axial shift. In order to prevent the opposite-direction shift they are limited by a frontally grinded washer 21 which are fitted in the larger diameter seats 18. The washers 21 are limited for the prevention of an axial shift by circlip rings 22 which are fitted in the grooves 19 of the seats 18. Near to the central orifices 16 in the wall of every cylinder head 4 and 5, there are orifices 23 and 25 connected to the inner cylinder spaces of

every cylinder 2. Regarding the first variant in reference with fig. 1, in the first of the orifices 23 is statically mounted a glow plug 24 and in the second one 25 - a fuel-injection nozzle 26 connected by a pipe to a fuel-injection pump with a high operating pressure of the injected fuel. Regarding the second variant in reference with fig. 2, in both the orifices 23 in the heads 4 and 5 are mounted ignition plugs 24 and the fuel-injection nozzles are mounted in orifices 25 of the cylinders 2 (nearer to the exhaust channels 7).

Inside each cylinder 2 is coaxially installed a mobile hollow two-stroke piston 27 (further on referred only as 'pistons 27') provided in their top heads with coaxial central thin-wall tube-like air-conductors 28. The latter are suited in the central orifices 16 which have seats 17 and 18, rings 20 and washers 21 of the top head 4. The bottom piston 27 heads are statically connected to coaxial central piston rods 29.

The piston rods have central blind holes 30 connected to the piston 27 cavities and are suited in the central orifices 16, their seats 17 and 18, rings 20 and washers 21 of the bottom head 5. At a distance equal to the pistons 27 travel in the cylinders 2 (measured from their front heads), in the walls of the air-conductors 28 and piston rods 29 there are scavenging holes 31. Inside the pistons 27 (assembled of two parts which are statically fixed) are installed immobile inner hollow thin-wall bodies 32 having smaller diameter and length. The thin-walled bodies 32 designed to ameliorate the pistons 27 cooling are immobile fixed to the pistons heads by central coaxial tube-like tails 33. In the walls of these thin-wall tube-like tails 33 there are holes 34 connecting the cavity between the pistons 27 heads and the bodies 32 to the cavities in the air-conductors 28 and to the blind holes 30 in the piston rods 29. In the ambient walls of the pistons 27 are cut exterior grooves 35 which are situated near the pistons heads. In each groove 35 which have grinded front walls, are mounted two (or more) cut metal (or metalographitic) outside-sealing rings 36. The rings 36 are grinded externally and frontally.

The free ends of the two piston rods 29 are connected to crossheads 37 which are mounted within orifices 38 in the engine's body and are coaxial to the cylinders 2. The crossheads are connected by a hinge to the top hubs 39 of the connecting rods 40 of the crankshaft mechanism. This is realized by knuckle pins 41 through mounting holes 42 in the engine's body 12. After the mounting of the wrist pins 41 and the limiting circlip rings 43 the holes 42 are pressurized by the caps 44 and their gaskets 45. The piston rods 29 could be connected by also using another mechanism transferring the rectilinear reciprocal motion into a rotary one.

The oil system provides the through-channel lubrication of the bearing units of the crankshaft 46, the connecting rods 40 and the

crossheads 37 by using high-pressure oil which is fed from an oil pump, sucking the oil from the crankcase 47 of the engine.

The cylinders 2, pistons 27, piston rods 29 and air-conductors 28 are not oiled by the oil system of the engine. An additional lubricating substance (in case the seal rings 20 and 36 are made from metalographitic material) is the injected fuel and the soot formed by the fuel combustion inside the cylinders 2. When the seal rings are metal ones then it is imperative that in the injected fuel must be added a very low content of oil or, otherwise, the air after the turbo-compressor 10 must be oiled. The two pistons 27 have an intense heat load which requires the cooling of their heads and walls. This, as mentioned above, is done coercively by the air-flow, blowing down and filling the inner spaces of the two cylinders 2. The air flows through the air-conductors 28 and through the orifices 34, goes into the cavity between the pistons 27 and the bodies 32, then passes through the other orifices 34 and flows into the blind holes 30. After that the air passes through the scavenging orifices 31 in the piston rods 29 and flows into the bottom inner spaces of the two cylinders 2. Along its way the air blows down and in the same time cools the pistons' 27 heads and walls and the inner surface of the bottom cylinder heads 5. The air, feeding the top inner spaces of the cylinders 2 flows into them through the tube-like air-conductors 28, blowing down and cooling the inside surfaces of the top heads 4.

## USAGE OF THE INVENTION

The engine shown on fig. 1 and 2 operates as follows:

The crankshaft 46 of the engine is rotated in its rotary direction by a starter. The crankshaft drives the bottom end of the connecting rods 40 and ejects rectilinearly and reciprocally their top end which is connected by knuckle pins 41 to the crossheads 37 and through them to the piston rods 29. The crossheads 37, piston rods 29 and the connected to them pistons 27 and air-conductors 28 are moving rectilinearly and reciprocally in their orifices 38, 16 and in the cylinders 2, in which the former are installed. In the presence of mutually antithetical motion of the pistons 27 in the cylinders 2, using their two heads they realize one-stroke gas-distribution mode. Simultaneously reaching top and bottom dead centre respectively by the two pistons 27 provokes an injection of a portion of fuel in the compression chambers of cylinders 2 and the synchronically beginning of the 'expansion' stroke. The 'exhaust' stroke begins simultaneously in both the cylinders 2 when the exhaust orifices 6 are opened by the heads of the two pistons 27. The 'cylinder scavenging and

fresh air filling' stroke (performing one-direction coercive gas-exchange) lasts at the time of 'burnt gases exhaust' stroke but begins a little bit later, and finishes a little bit earlier, e.g. when the scavenging orifices 31 of the air-conductors 28 and the piston rods 29 enter simultaneously the inner spaces of the two cylinders 2. The compression processes (strokes) in both the cylinders 2 are executed simultaneously in the top half of the first cylinder and the bottom half of the second cylinder, and vice versa, after the finishing of 'burnt gases exhaust' stroke till the moment of their simultaneous reaching of top and bottom dead centre (respectively) by their pistons 27. The burnt gases flow through the exhaust orifices 6, exhaust channels 7 and manifold pipe 8 and blow and rotate the impeller 9 and the delivery turbine 15 of the turbo-compressor 10.

Regarding the petrol engine variant which is shown on fig. 2, the fuel is introduced directly in the cylinders 2 by the fuel-injection nozzles 26 till the moment of the beginning the 'air-compression' stroke in each cylinder's inner space.

# PATENT CLAIMS

1. An internal-combustion turbo-compressor engine with a direct fuel injection in its cylinders, including cylinder block in which double-stroke pistons are installed and are connected to a crankshaft mechanism installed in the engine's body, distinguishing with the fact that in the centre of the cylinders (2) there is at least one exhaust orifice (6) connected through an exhaust channel (7) and a manifold pipe (8) to the turbo-compressor (10). Every cylinder (2) is hermetically double covered with top (4) and bottom (5) cylinder heads having central orifice (16), and the double-stroke pistons (27) are hollow and immobile connected through their top heads to central coaxial tube-like air-conductors (28), and through their bottom heads - to hollow piston rods (29) mached in the central orifices (16) of the cylinders heads (4, 5). The air conductors (28) and the hollow piston rods (29) are provided with scavenging holes (31) situated from the pistons (27) heads at a distance which is equal to the pistons' (27) travel. In the piston's (27) cavity is statically mounted a hollow thin-wall body (32) for an intense cooling of the piston (27). The top cylinder heads (4) of the cylinders (2) are hermetically covered with a hood (13) which inner space is connected to the delivery pipe (14) of the turbo-compressor (10).

2. An internal-combustion engine (ICE) in reference with claim 1, distinguishing with the fact that considering the HP fuel-injection performance, the fuel-injection nozzles (26) and the glow plugs (24) are mounted to the cylinders heads (4 and 5) of the engine.

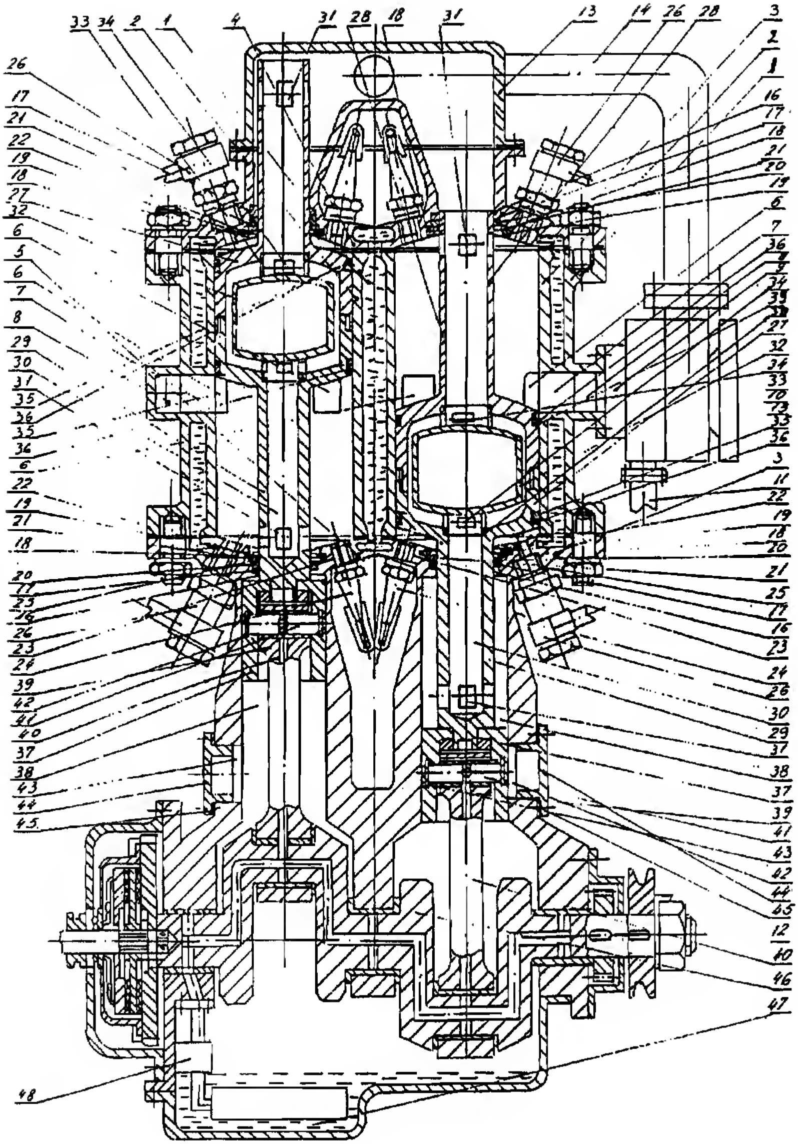
3. An ICE in reference with claim 1, distinguishing with the fact that considering the HP fuel-injection performance, the fuel-injection nozzles (26) are mounted to the cylinders (2).

4. An ICE in reference with claim 1, distinguishing with the fact that the double-stroke pistons (27), the air-conductors (28) and the piston rods (29) are sealed in the cylinders (2) and the central orifices (16) by at least two rings (36) and (20) situated in one groove (35) and (17).

5. An ICE in reference with claim 1, distinguishing with the fact that the hollow thin-wall bodies (32) installed in the two-parts assembled pistons (27) are connected to the pistons' heads via thin-wall tails with provided holes (34) in order to link the cavity of the pistons (27) with the air-conductors (28), and the blind hole (30) in the piston rod (29) respectively.

6. An ICE in reference with claim 1, distinguishing with the fact that the piston rods (29) are connected via crosshead (37) to a crankshaft mechanism.

7. ICE in reference with claims 1 and 6, distinguishing with the fact that the piston rods (29) are directly connected to another mechanism which can transfer the rectilinear reciprocating motion to an rotary one (or vice versa).



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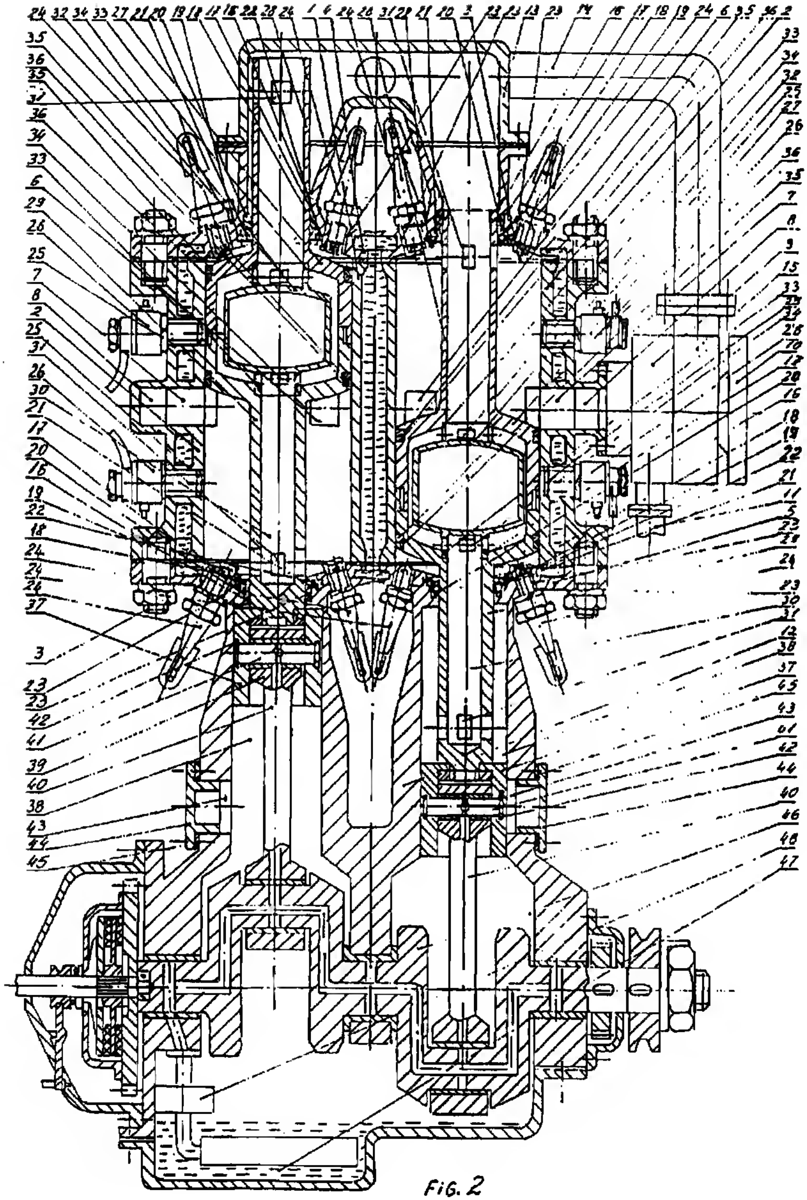

FIG. 2

# INTERNATIONAL SEARCH REPORT

In. ..ational Application No
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**A. CLASSIFICATION OF SUBJECT MATTER**
IPC 6 F02B75/00

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**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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Information on patent family members

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